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Research Paper

# Assessment of Knowledge and Attitudes of Radiotherapy Professionals Towards Prevention of Incidents during Treatment in Nigeria

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## Abstract

This study assessed the attitudes and knowledge of radiotherapy professionals towards prevention of incidents or accidents during cancer treatment in Nigeria. A cross-sectional study was conducted among Medical Physicists (MPs), Radiation Oncologists (ROs) and Radiation Therapists (RTs) at 9 radiation oncology centers in Nigeria as of December 2018. The questionnaire comprising 50 questions relevant to the study were administered following ethical approval by the Institutional Ethics Committee. SPSS version 20.0 was used for data analysis and results are presented in tables and figures. 83 (65.9%) of 126 population participated in the study. Mean cumulative percentages of 81.33 ± 16.68 and 89.55 ± 8.47 were obtained respectively for participants' attitude towards radiation safety practices and their knowledge of the role played by MPs in incidents' prevention. However, of the 83 respondents, 25.3%, 31.3%, 20.5% and 20.5% affirmed previous occurrences of Co-60 retraction failure, off-target dose delivery, interchange in field sizes and dose delivery to a different patient in external beam radiotherapy respectively. The mean difference of knowledge scores between RTs and ROs ($p = .012$) and between RTs and MPs ($p = .000$) were statistically significant. Accidents or incidents could occur in radiotherapy due to technical and human errors. This was a maiden work to characterize radiotherapy incidents and various responders in a national study. The study demonstrated that medical physicists, with the cooperation of ROs and RTs have a pivotal role to play in preventing radiotherapy incidents.

Keywords: Incidents, Accidents, Radiotherapy, Safety, Medical physicists.

## Introduction

The importance of radiotherapy to radiation medicine, specifically cancer management is high and should not be underestimated. Globally, there is a growing need for radiation therapy due to increased burden of cancer, which is no respecter of human gender or age. Nigeria with the highest population (over 200 million as of 2019) in Africa [1, 2] lags considerably in management of cancer due to the dearth of radiation equipment to meet up with the huge demand for treatment in the country. Despite this limitation, radiotherapy professionals maximize the limited infrastructures to provide healthcare services to the teeming cancer patients in the country. While radiotherapy has potential benefits to mankind, it can engender harm, complications in health and even death if stringent measures are not taken against such. In the Nigerian settings, where massive patients' workloads largely outweighs the grossly inadequate infrastructures, there is a tendency to ignore some quality assurance tasks while aspiring to reduce patients' waiting time for radiotherapy. Whereas, the performance of vital aspects of quality assurance could prevent occurrence of some unintended events. Unintended exposures or incidents in radiotherapy are likely to occur when certain conditions that favour such exposures exist [3]. The International Atomic Energy Agency (IAEA) has publications relevant to safety in radiotherapy practices [4, 5]. These were formulated based on experience from incidents, either from formal reporting systems or by informal dissemination of such information in the radiotherapy communities.

Accident in radiotherapy is any severe unintended event, including an operating error, equipment failure or other mishap, the consequences of which cannot be ignored from the protection or safety point of view, and which usually leads to potential overexposure or to abnormal exposure conditions for patient during treatment, staff or the general public [6].

In the context of this study, an 'incident' could be defined as an event that has led to, or would have led to if undiscovered, dose errors to a patient undergoing radiation therapy. All radiotherapy procedures involve risk because even a small error in treatment planning, delivery, or dosimetry can lead to negative consequences [7]. The team of professionals involve in radiotherapy procedures include Radiation Oncologists, Medical Physicists, Radiotherapy Radiographers, and others.

One of the statutory responsibilities of medical physicists (MPs) is radiation safety of personnel, patients, and members of the public. But it is expedient that members of the radiotherapy team play their role to assure avoidance of unintended events during the procedure. This study was therefore aimed at assessing the knowledge and attitudes of radiotherapy professionals towards prevention of incidents and accidents during cancer management in Nigeria.

## Material and Methods

A cross-sectional study was carried out among three categories of health professionals working at the 9 radiotherapy centers available in Nigeria as of 2018. Ethical approval was duly obtained from Medical Research and Ethics Review Committee of the University of Ibadan/University College Hospital, Ibadan prior to commencement of this study. A self-structured questionnaire was designed to acquire data related to the scope of the intended study.

*Study Population*

The target population included a defined workforce namely medical physicists, radiation oncologists and therapy radiographers working at hospitals where radiotherapy (external beam radiotherapy and/or brachytherapy) is practiced in the country.

*Sample Size Determination*

The desired sample size (n) for this study was determined using Slovin's formula as follows:

$$n = \frac{\mathbf{N}}{1 + \mathbf{N}\,(e^2)} \qquad (1)$$

where N (= 126) is the estimated target population, e is the level of precision (5 % precision).

Applying Slovin's equation: n = [126] / [1+126 (0.05)$^2$] n = 126/1.3225 = 95

*Data Acquisition*

The data for this study was acquired with the aid of self-structured questionnaires used to obtain individual responses and views on issues regarding the subject of interest. The research tool comprised six sections. While the first section contained 10 questions seeking socio-demographic information of the participants, the second and third sections are composed of questions regarding external beam radiotherapy (EBRT) and brachytherapy practices respectively. The fourth section sought to determine the level of knowledge of the participants about the significant role expected to be played by medical physicists in a bid to promote safety and quality in radiotherapy. The fifth section dealt with issues regarding environmental and personnel radiation safety. The sixth and final section was open-ended and availed respondents the opportunity to share their experience-based thoughts on potential sources of errors in radiation therapy that were not captured in the preceding sections. Besides, it gave room for further remarks on how MPs should play the role of averting or minimizing incidents in radiotherapy. Questions on attitude towards radiation safety practices contained in sections 2 and 3 and those on personnel's knowledge on the subject matter highlighted in section 4 were duly scored. Responses in sections 2 and 3 were scored 2, 1 and 0 if correct (Yes), no idea (I don't know) and wrong (No) answers were given respectively. Responses marked 'not applicable (NA)' were however excluded in the scoring process. Total scores calculated for everyone were translated into cumulative percentages and the mean value obtained. On the other hand, responses including 'strongly agree', 'agree', 'undecided', 'disagree' and 'strongly disagree', in section four were scored 5, 4, 3, 2 and 1 point (s) respectively.

*Data Analysis*

Statistical package for social scientists (SPSS Version 20) was used to carry out data analysis. Socio-demographic variables are presented as frequencies in tabular and graphical forms. Classifications of participants according to assessment scores and feedback received in response to questions asked are presented in tables and figures. Regarding knowledge scores of participants on a scale of 5.0, one sample t-test was performed to compare the mean of our sample data with a known (minimum) value (3.6) that serves as the benchmark for high score. Further analysis was performed to test if statistical differences exist among the mean scores on knowledge of MPs, ROs and RTs on the responsibilities of medical physicists towards prevention of incidents (and accidents). For all analysis done, confidence interval was 95%, and P values less than 0.05 % were regarded as significant.

## Results

Eighty-three (83) (indicating 65.9 % response rate) people whose social-demographic characteristics are presented in Table 1, consented, and participated in the study. About 50 % of the participants were within ages 36 and 45 years. The distribution of the participating MPs, ROs and RTs across the nine radiation oncology centers as of 2018 are shown in Figure 1. Table 2 presents responses given to questions on radiation safety practices. The attitudinal responses were translated into scores and the outcomes are highlighted in Table 3. In Figure 2, the response rates of participants to occurrence of incidents during radiotherapy administration were shown. Figure 3 shows the distributions of participants based on responses provided by them on assignment of quality control role in radiotherapy. In Figure 4, the distributions of participants based on responses provided to questions on safety and quality issues in radiotherapy are shown. Fig. 5 portrays the distribution of scores among the participants while highlighting the sample mean and deviation. Table 4 presents statistical parameters on knowledge scores. The differences between the means are statistically significant (p = .000). In Table 5, the results of Tukey's post-hoc test show that the mean difference of knowledge scores between RTs and ROs (p = .012) as well as between RTs and MPs (p = .000) were found to be statistically significant at 95% confidence interval.

**Table 1.** Socio-demographic characteristics of participants (n = 83)

| Variables | Frequency | Percentages |
|---|---|---|
| **AGE** | | |
| **25-35** | 18 | 21.7 |
| **36-45** | 41 | 49.4 |
| **> 45** | 24 | 28.9 |
| **GENDER** | | |
| **Male** | 62 | 74.7 |
| **Female** | 21 | 25.3 |
| **MARITAL STATUS** | | |
| **Single** | 14 | 16.9 |
| **Married** | 68 | 81.9 |
| **Others** | 1 | 1.2 |
| **EDUCATIONAL LEVEL** | | |
| **B.Sc** | 20 | 24.1 |
| **M.Sc** | 28 | 33.7 |
| **PhD** | 4 | 4.8 |
| **MBBS and related qualifications** | 31 | 37.3 |
| **Geo-political zone** | | |
| **North Central** | 8 | 9.6 |
| **North East** | 4 | 4.8 |
| **North West** | 18 | 21.7 |
| **South East** | 6 | 7.2 |
| **South South** | 12 | 14.5 |
| **South West** | 35 | 42.2 |
| **PROFESSIONAL CATEGORY** | | |
| **Radiation Oncologists** | | |
| **Medical Physicists** | 32 | 38.5 |
| **Therapy Radiographers** | 30 | 36.1 |
| | 21 | 25.3 |
| **LEVEL OF ENGAGEMENT** | | |
| **Clinical** | 50 | 60.2 |
| **Academic** | 1 | 1.2 |
| **Both** | 32 | 38.6 |
| **Years of Experience in RT** | | |
| **< 1** | 2 | 2.4 |
| **1 – 3** | 18 | 21.7 |
| **4 – 6** | 11 | 13.3 |
| **> 6** | 52 | 62.7 |

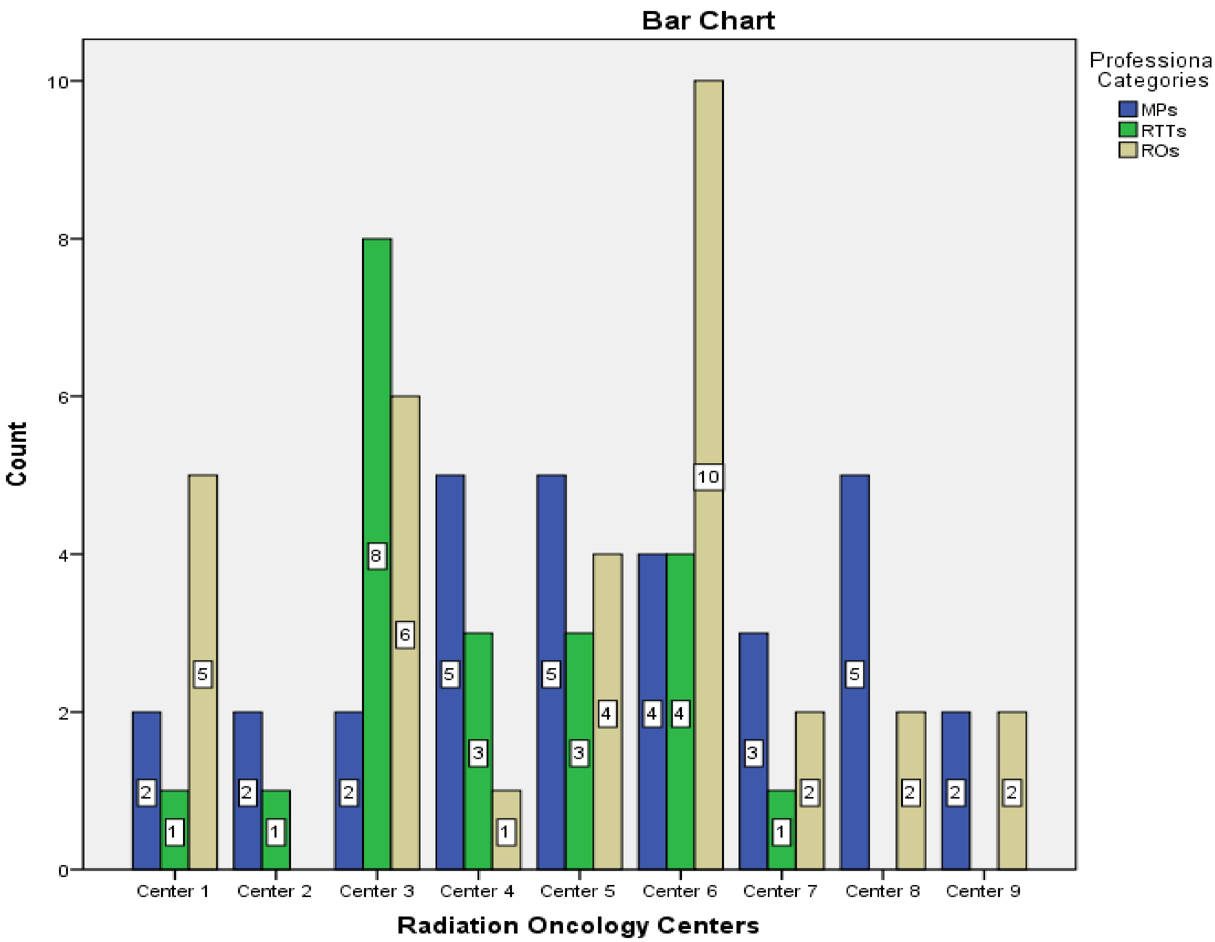


**Figure 1. Distribution of study participants across the 9 radiation oncology centers**

**Table 2.** Feedback from the respondents (n = 83) to issues regarding Radiation Safety Practices

| Questions | Not Aware n (%) | Yes n (%) | No n (%) | NA n (%) |
|---|---|---|---|---|
| Was Acceptance testing done after installation of EBRT equipment? | 10 (12) | 68 (81.9) | 0 (0) | 5 (6) |
| Was there technical commissioning following Acceptance Testing? | 10 (12) | 68 (81.9) | 0 (0) | 5 (6) |
| Is there daily QC checks on teletherapy units | 6 (7.2) | 61 (73.5) | 6 (7.2) | 10 (12.0) |
| Is there a practice of computerized treatment planning (CPT) in EBRT? | 6 (7.2) | 43 (51.8) | 32 (38.6) | 2 (2.4) |
| Are quality control tests often done on your simulator? | 4 (6) | 25 (30.1) | 9 (10.8) | 43 (51.8) |
| Are at least 2 MPs often involved in dose calculations or CPT for a given patient? | 0 (0) | 67 (80.7) | 13 (15.7) | 3 (3.6) |
| Are at least 2 RTs often involved in treatment delivery of each patient? | 0 (0) | 55 (66.3) | 25 (30.1) | 3 (3.6) |
| Is radiation survey often carried out within your radiotherapy facility? | 4 (4.8) | 28 (33.8) | 51 (61.4) | 0 (0) |
| Do you have at least 1 functional radiation survey meter at your radiotherapy facility? | 7 (8.4) | 69 (83.13) | 7 (8.4) | 0 (0) |
| Is any of the survey metres within a valid calibration period? | 16 (19.3) | 57 (68.7) | 8 (9.6) | 0 (0) |
| Is there always a further check of radiation level in BT room using a survey meter immediately after dose delivery? | 5 (6) | 22 (26.5) | 6 (7.2) | 50 (60.2) |
| Are all personnel working within the radiotherapy facility monitored with dosimeters? | 1 (1.2) | 76 (91.6) | 6 (7.2) | 0 (0) |

**Table 3.** Classifications of Participants' scores on attitude to radiation safety practices

| Performance Grading | Mean | Frequency | Cumulative (%) |
|---|---|---|---|
| **High Quality** | 1.6 – 2.0 | 53 | 80 and above |
| **Acceptable** | 1.2 – 1.59 | 20 | 60 - 80 |
| **Improvement Required** | Less than 1.2 | 10 | < 60 |
| **Combined** | 1.63 ± 0.33 | 83 | 81.33 ±16.68 |

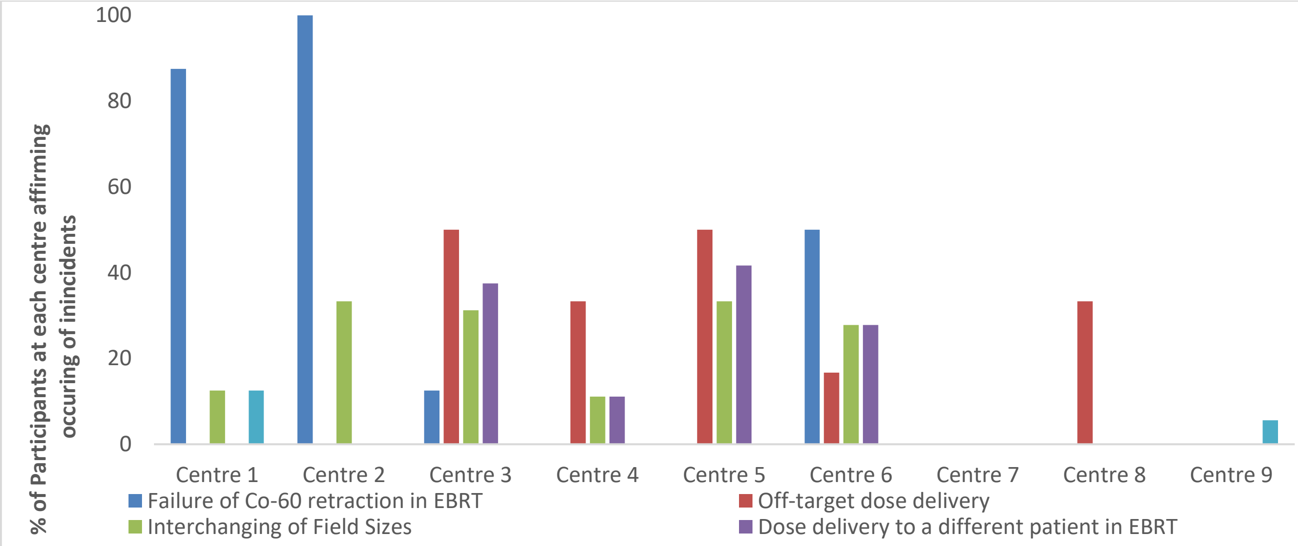


**Figure 2. Response rates of participants to occurrence of incidents during radiotherapy administration**

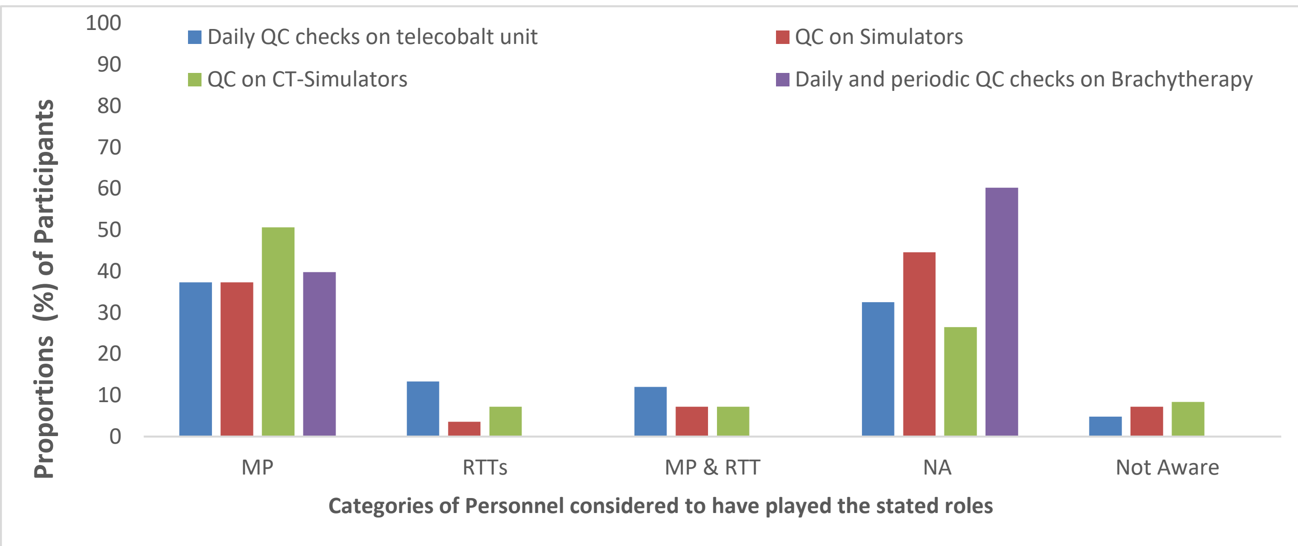


**Figure 3. Distributions of participants according to responses provided on the role they play on quality control tasks**

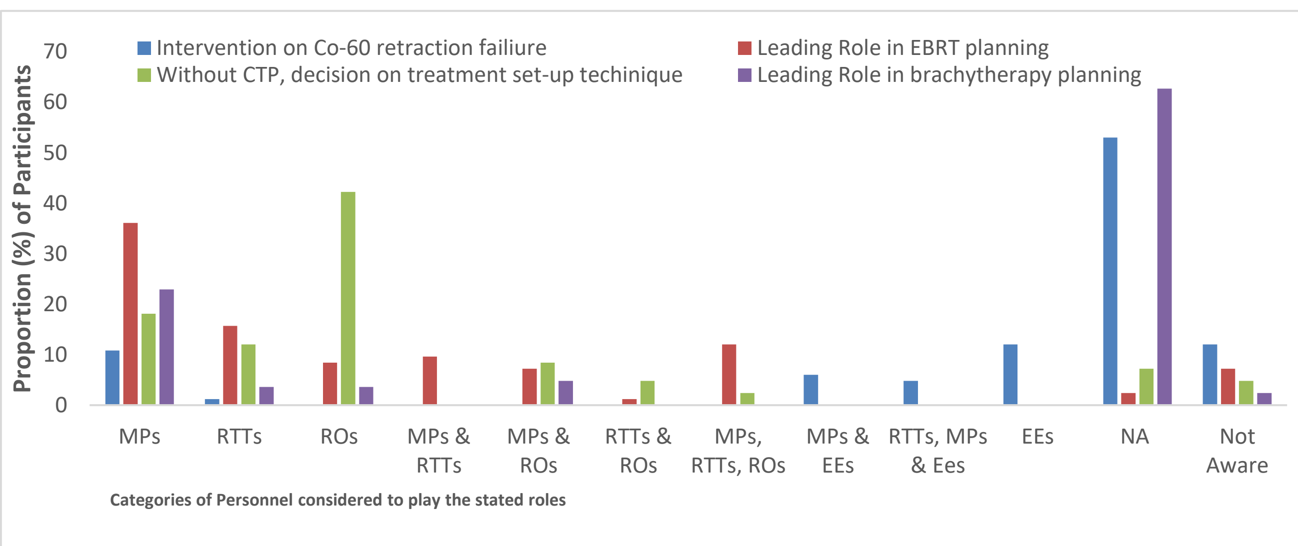


**Figure 4. Distributions of participants according to responses provided on certain tasks vital to safety and quality in radiotherapy**

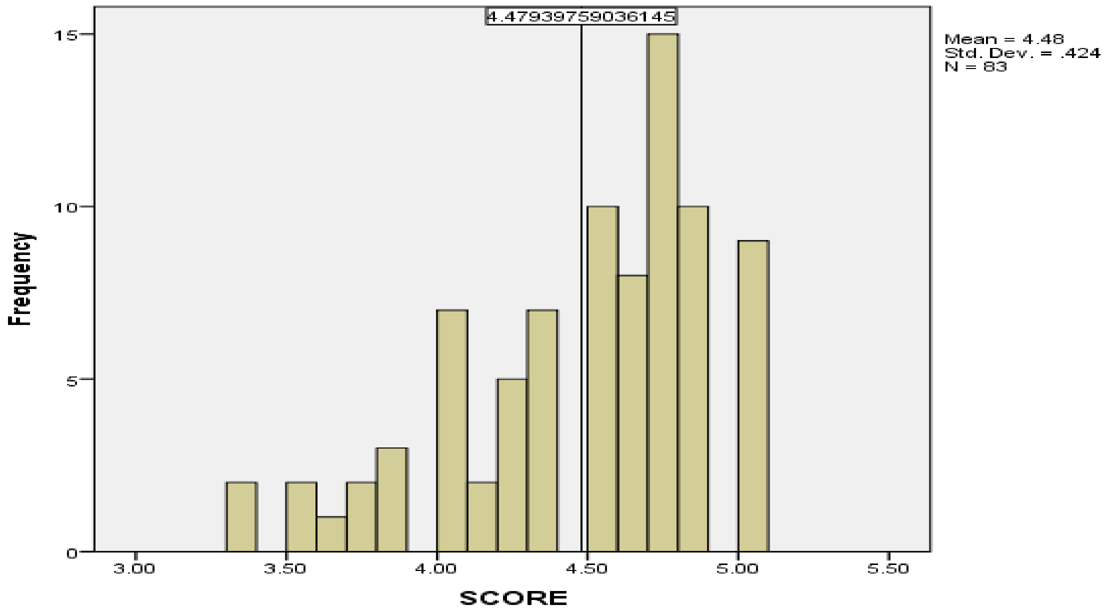


**Figure 5. One-Sample Test (Test Value = 3.6), Sig. (2-tailed) = .000, Mean Difference = .87940 (The score on knowledge is statistically different from 3.6 which is the minimum required for high level of knowledge).**

**Table 4.** Descriptive of participants' scores on knowledge of responsibilities among multi-disciplinary personnel in the radiotherapy process

**Knowledge Scores**

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| **MP** | 30 | 4.6433 | .33696 | .06152 | 4.5175 | 4.7692 | 3.75 | 5.00 |
| **RT** | 21 | 4.1924 | .44933 | .09805 | 3.9878 | 4.3969 | 3.38 | 4.88 |
| **RO** | 32 | 4.5141 | .39379 | .06961 | 4.3721 | 4.6560 | 3.50 | 5.00 |
| **Total** | 83 | 4.4794 | .42358 | .04649 | 4.3869 | 4.5719 | 3.38 | 5.00 |

**Table 5.** Multiple Comparisons of knowledge scores of Nigerian Radiotherapy personnel using Tukey HSD test

**Dependent Variable: Knowledge Scores**

| (I) Professional Category | (J) Professional Category | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| **MP** | RT | .45095* | .11083 | .000 | .1863 | .7156 |
| | RO | .12927 | .09899 | .396 | -.1071 | .3657 |
| **RT** | MP | -.45095* | .11083 | .000 | -.7156 | -.1863 |
| | RO | -.32168* | .10939 | .012 | -.5829 | -.0604 |
| **RO** | MP | -.12927 | .09899 | .396 | -.3657 | .1071 |
| | RT | .32168* | .10939 | .012 | .0604 | .5829 |

## Discussion

Radiotherapy is an increasingly important tool in the treatment of patients diagnosed with cancer. The use of radiotherapy to treat a wide range of cancers has grown in recent years and considerable investment is needed to meet current and future demand. It had been estimated that radiotherapy contributes to around 40 % towards curative treatment of cancer patient [8].

Timely access to radiotherapy leads to improvements in cancer care and survival rates, thus providing further cost benefits [9]. Unfortunately, there were only 9 radiotherapy centers (Figure 1) in a country of over 200 million people [1, 2] as of 2019 when this study was conducted. This greatly limited the accessibility of patients in each of the geo-political zones to Radiotherapy facilities. Majority (76%) of the participants in this study had spent over 3 years (Table 1) at their respective radiotherapy centers and were in best position to provide reliable feedback on their professional experiences.

Incidents or accidents occur in every field of human endeavor including medicine and radiation oncology practice is not an exception. However, the level of knowledge and. attitude of radiotherapy professionals involved would determine the frequency and severity of unintended events during cancer management.

Radiation oncologists as medical personnel are specialized in the treatment of cancer. They however work closely with medical physicists, therapy radiographers and other professionals whose responsibilities are crucial to successful cancer management. Radiation safety practices some of which are enumerated in Table 2 are essential to assuring safety and quality in radiation therapy. Acceptance testing and technical commissioning of radiotherapy equipment are critical tasks that require implementation prior to clinical procedures. Majority of the respondents affirmed that this process was completed for external beam radiotherapy (EBRT). The few exceptions comprised those whose institutions did not have teletherapy equipment and those who had not been employed at the time of machine procurement.

Regarding the question on whether at least 2 MPs and 2 RTs were present during radiotherapy treatment process, affirmative response was given by 80.7 and 66.3 % (Table 2) participants respectively. Higher percentages in positive response would have resulted if the staffing levels were adequate at all the centers. The involvement of only 1 personnel in any professional category during the complex chain of radiation therapy is totally wrong, as it increases the chances of oversights, resulting in avoidable incidents. The situation would be worse if the only staff available is deficient in training for the task to be carried out. Some previous studies had summarized guidelines on clinical staffing for radiotherapy facilities and opined that the ability to deliver safe and quality radiotherapy would be compromised by inadequate staffing levels [10-12]. The guidelines were based on recommendations of notable international organizations [13, 14]. It is therefore important to have adequate human resources with the right training across the various professions involved in cancer care.

Our study noted that approximately one-third of the participants could attest to regular (Table 2) radiation survey within the radiotherapy facilities. Frequent environmental radiation monitoring could aid prompt identification of unwarranted over-exposures so that a timely intervention is made. Irregular monitoring could be duly attributed to lack of calibrated radiation survey meters and inadequate MP staffing. A previous article [15] had reported the importance of exposure monitoring given that anyone who works in a setting with a known radiation source is at risk of radiation effects which include cancer. This important safety check should therefore be taken more seriously especially at centers indicated by some participants' responses. The feedback obtained from respondents showed that medical physicists play a considerable role in the multi-faceted process of averting or minimizing incidents in radiotherapy. This is evident from Fig. 3 which shows proportions of participants responding to personnel category performing some quality control tasks in radiotherapy.

The statutory role of medical physicists in radiotherapy would normally include treatment planning and clinical dosimetry. The diverse responsibilities of medical physicists had been highlighted in the report of a professional organization [16]. In a previous article the need for physicists to be involved, at least to some extent, in treatment planning and clinical dosimetry for each patient was indicated [17]. This place a huge responsibility on them to ensure that certain preventive measures against unintended events are taken.

Our survey (Figure 2) shows that most of the radiotherapy centers that participated in this study had encountered one or more of radiotherapy incidents including failure of Cobalt-60 retraction in EBRT, off-target dose delivery and interchange of field sizes. Another which was least expected was dose delivery to a different patient requiring teletherapy. The Australian policy directive on clinical procedure safety states that accurate treatment delivery starts with patient identification which include having the right patient, treating the correct site and using the right procedure [(18)]. We would recommend that incident reporting culture should be imbibed at each hospital to promptly create learning opportunities from undesirable events and prevent future re-occurrences.

This study recognized that all professionals in the radiation therapy pathway have important responsibilities to fulfill in order to minimize adverse radiation events. However, medical physicists have a central role to play and should as part of quality management system adhere to international radiation safety protocols and participate in independent radiation safety audits.

Some of these incidents reported above would have been averted if all the issues regarding radiation safety practices obtained from the respondents and presented in Table 2 were 100 % in the affirmative. In a previous article [7], Malicki had succinctly mentioned the duties of the radiation oncologist, medical physicist and technologist and the susceptibility of the related steps to errors. As with the present study, the aim of the previous editorial [7] was not to focus on human mistakes but rather to examine the diversity of errors which are related to planning, patient set-up and delivery that can result in harmful irradiation outside of the target area. One useful way to work when resources are very limited is for healthcare professionals to talk to each other between centers and set up some sort of internal audit in order to be guided and identify loopholes that could result in incidents.

The response of the respondents on issues related to the critical task of radiation quality control (QC) measurements, such as daily and periodic checks on radiotherapy equipment including teletherapy and brachytherapy units, radiotherapy simulator have been presented. It can be seen that the Medical Physicists (MPs) take the lead even though the RTs do part of these tasks, either alone in a situation when they are the first respondent, (being the operator of such units) or with the supervision of MPs (Figure 3).

The feedback (Table 4) from this study showed that medical physicists have a crucial role to play in intervention of Cobalt-60 retraction failure, treatment planning and as well as in the decision-making process of treatment set-up technique. The position of radiation safety officer is often occupied by medical physicists, especially in radiotherapy facilities. A published report had asserted that RSO of institutions has the responsibility to develop adequate warning instructions and the required actions consequent to source stuck situations. Such efforts would include the conduct of mock drill to show the actual scenario as a pseudo practice [19]. We recommend that this preparatory arrangement should not be limited to telecobalt machine but be extended to brachytherapy equipment which also utilize radioisotopes. Unfortunately, medical physics career in Nigeria has been faced with poor recognition and training, with a potential negative impact on cancer care delivery. Recognition of the prospective career path by undergraduate students in physics has been considerably low in the country [20]. An opinion paper had asserted that the supply of MPs must be ensured by educating schoolchildren to find science rewarding, and there must be a route into medical physics for people without too great a re-training impediment [21]. Many health professionals are also unaware of the clinical role of MPs because the latter hardly find a need to directly interact with the patients. In a review article, MPs are enjoined to take the lead in evaluating challenges associated with radiotherapy quality and safety [22].

About 88 % of the participants have satisfactory score on attitude to radiation safety practices. This implies that majority of the personnel are poised to respond positively to incident preventive measures when the opportunities present itself. Each of the professions has defined role in radiation protection, although, there is some overlap in responsibilities. This work would be of interest in enhancing quality management and radiation safety culture of radiotherapy practice, especially in radiotherapy departments that are very busy and under-resourced.

*Study limitation*

This work was intended to involve at least 95 (75.40 %) participants being the estimated sample size. But a lower response rate of 65.90 % (of 83 respondents) was achieved despite the frantic efforts made to encourage more participation. The work however presented findings which were noteworthy and should be given serious attention, in a bid to mitigate risks related to incidents or accidents in radiotherapy, especially in low- and middle-income countries.

## Conclusions

This study reports findings on the knowledge and attitudes of radiotherapy professionals towards prevention of incidents during cancer management. Incidents of varying degrees had been experienced in Nigeria. The level of knowledge among the multidisciplinary staff on circumstances that could elicit incidents was found to be high. However, a robust attitudinal approach including implementation of identified measures is required to assure safe practices, notwithstanding the level of infrastructure available. Globally, the role of MPs is central to resolving care delivery issues in cancer care and they should therefore be actively involved.

## Abbreviations

MPs: Medical Physicists; RO: Radiation oncologist; RT: Radiation therapist; IAEA: International Atomic Energy Agency; EBRT: External beam radiotherapy; QC: Quality control.

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## Author Contributions

All authors contributed to this study. All authors gave their final approval.

## Competing Interests

We declare no competing interests.

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